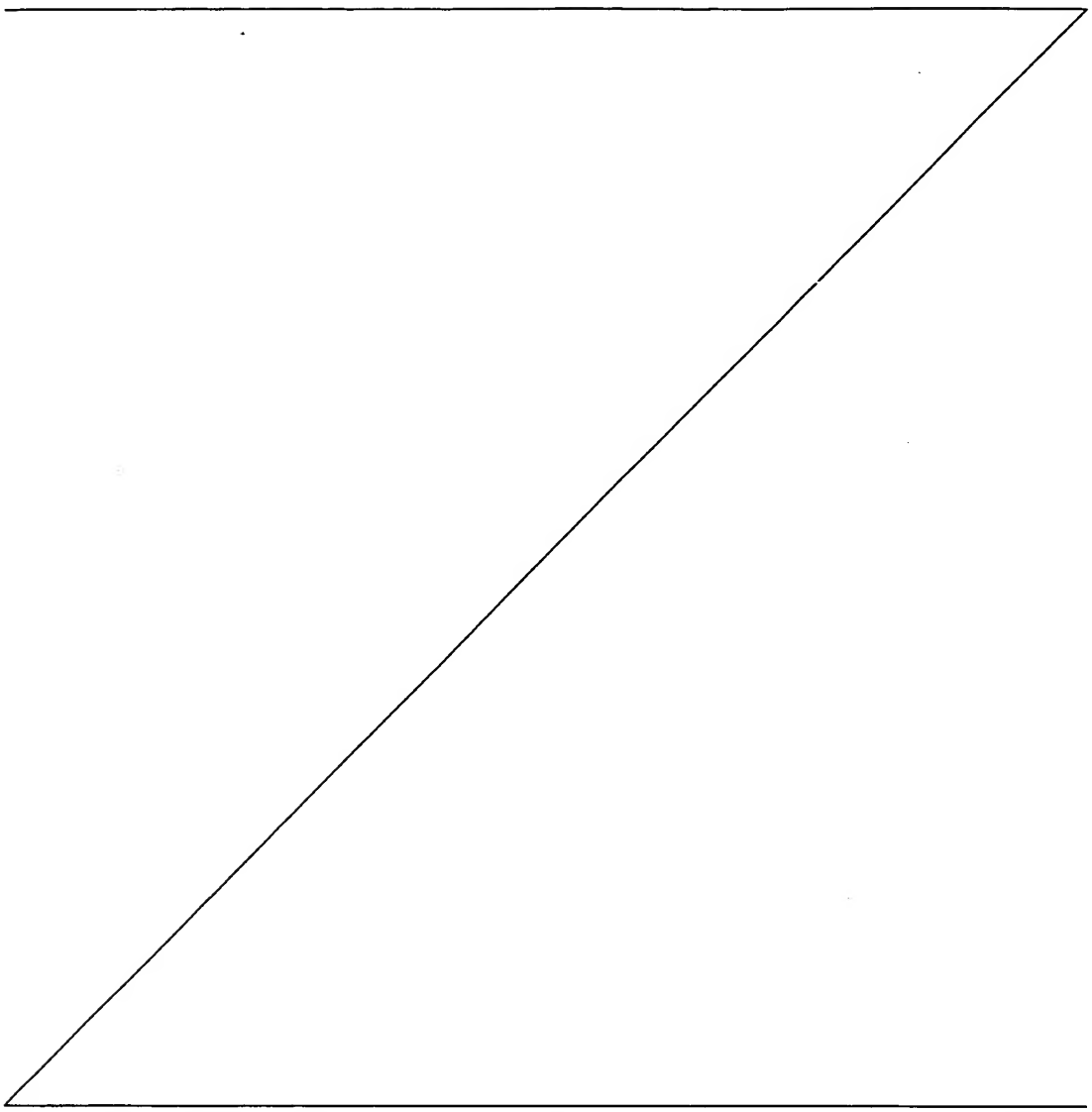

US 5,411,450 A describes a method for operating a drive train, with a prime mover, with an automatic transmission and with a power divider not power-shiftable and actuated by external force. Before the commencement of a shift of the power divider, a forward gear clutch of the automatic transmission is opened and the force flux between the prime mover and the power divider is thus interrupted. The shift in the power divider can subsequently be carried out. After the conclusion of the shift, the forward gear clutch is closed again.

GB 2 304 835 A likewise describes a method for operating a drive train, with a prime mover, with an automatic transmission and with a power divider not power-shiftable and actuated by external force. In the event of a shift and consequently in the event in a change in the step-up ratio of the power divider, a suitable gear is selected automatically in the automatic transmission.

EP 0 947 739 A2 describes a method for operating a group transmission of a commercial vehicle. An automated main transmission is followed by a range group. In the event of a required shift of the range group, a check is made as to whether a rotational speed of the prime mover after the shift is lower than a minimum rotational speed. If this is so, the shift is not executed.

WO 00/021812 A describes a motor vehicle with an automated shift transmission and with a device for preventing unwanted movement of the motor vehicle. In the event of an interrupted force flux between the prime mover and driven vehicle wheels, said device is activated in order to prevent a rolling of the motor vehicle, in particular opposite to the desired direction of travel.

The object of the invention is, in this respect, to propose a method for operating a motor vehicle, by means of which it becomes possible to operate the motor vehicle comfortably. The object is achieved, according to the invention by means of a method as claimed in claim 1.

According to the invention, in the presence of a shift requirement for the power divider, before the commencement of the shift a torque of the shifting

members involved in the shift is reduced automatically by a control device. The shift requirement may be a requirement for a change of a step-up ratio of the power divider or a changeover between two-wheel and four-wheel drive. This shift requirement may be triggered by the vehicle driver, for example by the actuation of a switch in the interior. Alternatively to this, the requirement may be generated by a control device as a function of operating variables of the motor vehicle and of environmental variables.

The reduction of the torque of the shifting members, for example gearwheels, sliding sleeve and/or synchronizing bodies, is necessary, since a shift, in particular a deselection of the shifted gear, is possible in non-power-shift transmissions only when no torque or only a very low torque is transferred by the shifting members which are in engagement.

The reduction can take place by means of the controlled setting of the output torque of the prime mover, for example to zero, or by separating the connection between the prime mover and the power divider.

After the reduction in the torque has taken place, the shift is carried out by means of the suitable activation of activating members with actuation by external force, that is to say without the assistance of the vehicle driver. The actuating members may be designed, for example, as electric motors or hydraulic or pneumatic piston/cylinder units. After the conclusion of the shift, the control device again permits a torque at the shifting members. For this purpose, the output torque of the prime mover is set again according to an instruction from the vehicle driver or the connection between the prime mover and power divider is restored. The instruction from the

vehicle driver is derived from a degree of actuation of a power actuating member, for example a position of an accelerator pedal.

The transmission may in this context be designed as a manual shift transmission or an automated transmission.

The transmission is designed as an automatic transmission. In order to reduce the torque of the shifting members, the control device interrupts, by the opening of a clutch, a force flux between prime mover and power divider which is produced by means of a positive or frictional connection. In particular, the control device opens a clutch in the automatic transmission, clutch also being understood as meaning a break in the automatic transmission. To open the clutch, the control device activates actuating members of the automatic transmission in a suitable form. Alternatively to a clutch in the automatic transmission, for example when an automated gearwheel change transmission is employed, a starting clutch arranged between the prime mover and the automatic transmission may also be opened. As a result of the opening of the clutch, the power divider is no longer connected to the prime mover, so that the result of the opening of the clutch, the power divider is no longer connected to the prime mover, so that the drive train is separated and is consequently free of torque.

After the conclusion of the shift, the control device restores the force flux by closing said clutch.

The automatic transmission may be designed, for example, as an epicyclic transmission, continuously variable transmission, double clutch transmission or automated gearwheel change transmission. The motor vehicle may have in each case for the prime mover, the

automatic transmission and the power divider a separate control device or control devices for simultaneously more than one of the assemblies mentioned.

Consequently, the torque of the shifting members can be reduced with a high degree of liability and it becomes possible to shift the power divider in a reliable way. Particularly in the case of distortions in the drive train, such as may occur, for example, on cross-country trips, the reduction in the torque of the shifting members by influencing the output torque of the prime mover is highly unreliable.

The motor vehicle has an activatable brake system which may be designed, for example, as an electrohydraulic brake system. By means of the brake system, a braking torque can be applied to the motor vehicle, independently of a position of a brake pedal, as a result of the activation of actuating members by a control device.

The control device of the power divider monitors the speed of the motor vehicle and/or variables derived from this during a shift of the power divider. Derived variables are, for example, a difference between a current speed and a speed of the commencement of the shift, an acceleration of the motor vehicle or a direction of travel.

As a function of the result of the monitoring, the control device activates the brake system at least indirectly. Activation takes place, for example, in that the control device sends a requirement for a braking torque to the control device of the brake system, this control device then implementing the requirement. After the conclusion of the shift, any requirement is canceled and therefore any braking

torque which is possibly present is reduced.

The shift of the power divider may take up a few seconds, for example up to three seconds. During this time, the driver train is separated, that is to say the prime mover is not connected to the driven vehicle wheels, so that no torque from the prime mover can act on the vehicle wheels. During this time, unwanted and uncontrolled movements of the motor vehicle may occur, for example when the motor vehicle is operated on a slope. By the speed of the motor vehicle and any activation of the brake system being monitored, active influence can be exerted on the movement of the motor vehicle in spite of the open drive train. Consequently, an especially reliable operation of the motor vehicle is ensured, and uncontrolled operation of the motor vehicle is prevented.

In the presence of a shift requirement, the control device calculates from the current speed of the motor vehicle and the step-up ratio in the drive train after the shift a rotational speed of the prime mover which occurs after the shift. This is relevant only when the step-up ratio of the power divider changes during the shift. A shift is carried out in the automatic transmission or the shift requirement is suppressed as a function of the calculated rotational speed.

The control device determines, in particular, a permitted range of the rotational speed of the prime mover after the shift. The range may be stored, for example, in the control device or be determined as a function of operating variables of the motor vehicle, such as, for example, the speed, and/or environmental variables, such as, for example, the slope of the road. If the rotational speed can be brought into said range by means of a simultaneous shift of the automatic

transmission, the shift of the automatic transmission and of the power divider is carried out. Very high step-up ratio jumps, for example of 2.6, may lie between step-up ratios of power dividers. This may correspond approximately to a shift from 2nd to 5th gear, for example, in the case of a 7-gear epicyclic transmission. Consequently, in the event of a shift in the power divider and a step-up ratio of the automatic transmission which remains the same, the rotational speed of the prime mover changes very sharply and may consequently lie very quickly outside the permitted range. This sharp change in rotational speed can be counteracted by a simultaneous change in the step-up ratio of the automatic transmission. To stay with the example mentioned, in the event of the shift of the power divider into a cross-country gear, that is to say into a lower step-up ratio, the step-up ratio jump of 2.6, the rotational speed of the prime mover can be kept virtually constant by means of a simultaneous shift of the automatic transmission from 2nd to 5th gear.

If, even as a result of a simultaneous shift of the automatic transmission, the rotational speed of the prime mover would lie outside the permitted range after the shift, the shift of the power divider is suppressed.

A large proportion of required shifts of the power divider can consequently also be executed. At the same time, however, the situation is prevented where the prime mover is in an unpermitted operating state after the shift, for example the rotational speed is too low or too high.

When the method according to the invention is employed, no actuation of a clutch by the vehicle driver is

necessary in order to execute a shift of the power divider. Should the driver wish to execute a shift, he merely has to trigger a shift requirement. The operation of the motor vehicle consequently becomes simpler and more comfortable for the vehicle driver.

In addition, by virtue of the method according to the invention, it is possible that the control device can decide whether a shift is appropriate and trigger this and carry it out without actions by the vehicle driver.

In an embodiment of the invention, during the shift of the power divider, the control device automatically reduces the output torque of the prime mover. The instruction from the vehicle driver by the power actuating member is in this case ignored. After the conclusion of the shift, the control device again permits an increase in the output torque, and the instruction from the vehicle driver is implemented again. The decrease and increase in the torque may take place, for example, along ramps.

Consequently, the vehicle driver can continue to actuate the power actuating member during a shift of the power divider, without the rotational speed of the prime mover, with the drive train open, rising in an unwanted way and unnecessarily. During the closing of the clutch, the risen rotational speed would in most instances have to be reduced again. The operation of the motor vehicle consequently becomes simpler and more comfortable.

In the embodiment of the invention, the control device activates the brake system when a false direction of travel is detected. A false direction of travel is present when the current direction of travel is opposite to the direction of travel desired by the

vehicle driver. This may be determined, for example, from the comparison of the current direction of travel with a position of the selector lever of the automatic transmission or with the direction of travel of the commencement of the shift. The current direction of travel may be determined by means of suitable rotational speed sensors on the vehicle wheels. The control device activates the brake system, in particular, to the standstill of the motor vehicle and subsequently holds the motor vehicle up to the conclusion of the shift. In this case, when the motor vehicle is subsequently started, a rolling opposite to the desired direction of travel can likewise be prevented. The function of what is known as a hill holder can thereby be implemented.

A false direction of travel may occur, for example, in the event of a shift of the power divider when the motor vehicle is driving up a steep slope at low speed. During this shift, the driver train is separated, and no drive torque from the prime mover acts on the motor vehicle. Due to the slope downforce, the motor vehicle is decelerated and, in the most unfavorable case, is accelerated opposite to the original direction of travel. The motor vehicle could move toward motor vehicles which may possibly be following it. By the brake system being activated, the unwanted movement can be prevented, and therefore safety-critical situations can be ruled out. This makes it possible to operate the motor vehicle particularly reliably.

In an embodiment of the invention, the control device activates the brake system if a difference of the current speed from an initial speed at the commencement of the shift and/or a speed gradient overshoot limit values. In particular, by means of a suitable braking torque, a constant differential speed or a constant

speed gradient, that is to say a constant acceleration, can be set.

This prevents the situation where the speed of the motor vehicle increases too sharply during a shift of the power divider. This situation may arise, for example, in the event of a shift when the motor vehicle is driving down a steep slope, since, with the drive train separated, there is also no engine braking action on the motor vehicle. The separation of the drive train may therefore lead to a sudden very sharp acceleration of the motor vehicle. This acceleration may be very surprising to the vehicle driver, and this may therefore lead to a safety-critical driving situation. By the brake system being activated when one of the conditions mentioned is fulfilled, the safety-critical driving situations described cannot arise, thus resulting in a particularly reliable operation of the motor vehicle.

Further embodiments of the invention may be gathered from the description of the drawing. Exemplary embodiments of the invention are illustrated in simplified form in the drawing and are explained in more detail in the following description.

In the drawing:

fig. 1 shows a detail of a drive train of a motor vehicle with a power divider, and

fig. 2 shows a flowchart of a method for operating the motor vehicle in the event of a shift of the power divider.

According to fig. 1, a drive train 10 of a motor vehicle, not illustrated, has an internal combustion engine 11 which is activated by a control device 12.

For this purpose, the control device 12 is signal-connected to actuating members, not illustrated, such as, for example, a throttle valve adjuster, and sensors, such as, for example, rotational speed sensors. Moreover, the control device 12 is signal-connected to a power actuating member 13 which is designed as an accelerator pedal and by means of which a vehicle driver can set an output torque of the internal combustion engine 11. The control device 12 can calculate from detected variables further operating variables of the internal combustion engine 11, for example the output torque of the internal combustion engine 11.

The internal combustion engine 11 is connected via a shaft 14 to an automatic transmission 15 which is

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Patent claims

1. A method for operating the drive train of a motor vehicle, with

- a prime mover (11),
- an automatic transmission (15),
- a power divider (20) actuated by external force and not power-shiftable, and
- at least one control device (12, 16) for activating the prime mover (11), the automatic transmission (15) and the power divider (20),

a shift being executed by the control device (16) in the presence of a shift requirement for the power divider (20),
and the control device (16),

- before the commencement of the shift, reducing a torque at the shifting members (23, 24, 25, 26) involved in the shift by an interruption in the force flux between the prime mover (11) and power divider (20) by the opening of a clutch (18), in particular a clutch (18) in the automatic transmission (15), and
- after the conclusion of the shift, restoring the force flux by the closing of said clutch (18) and permitting a torque again at said shifting members (23, 24, 25, 26),

characterized in that

- the motor vehicle has an activatable brake system (45),
- the control device (16) monitors the speed of the motor vehicle and/or variables derived from this during a shift of the power divider (20),
- the control device (16) activates the brake system (45) as a function of the result of the monitoring, and,

- in the presence of a shift requirement, the control device (16) calculates a rotational speed of the prime mover (11) occurring after the shift and carries out a shift in the automatic transmission (15) or suppresses the shift requirement as a function of the calculated rotational speed.

2. The method as claimed in claim 1, characterized in that the control device (12, 16)

- reduces an output torque of the prime mover (11) during the shift, and
- permits an increase in the output torque after the conclusion of the shift.

3. The method as claimed in claim 1 or 2, characterized in that, if a false direction of travel is detected, the control device (16) activates the brake system (45), in particular to the standstill of the motor vehicle.

4. The method as claimed in claim 1, 2 or 3, characterized in that, if a difference of the current speed from an initial speed of the commencement of the shift and/or a speed gradient overshoot limit values, the control device (16) activates the brake system (45).

5. The method as claimed in claim 4, characterized in that the control device (16) sets a constant differential speed or a constant speed gradient.

6. The method as claimed in one of claims 1 to 5, characterized in that a permitted range of the rotational speed of the prime mover (11) after the

shift is determined in the control device (16), and,

- if the rotational speed can be brought into said range by means of a shift of the automatic transmission (15), the shift of the automatic transmission (15) and of the power divider (20) is carried out, and,
- otherwise, the shift of the power divider (20) is suppressed.